

# Dr. Renyu Hu, Hubble Fellow

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## EDUCATION

- 2013     **Ph.D., Planetary Sciences**, Massachusetts Institute of Technology  
*“Atmospheric Photochemistry, Surface Features, and Potential Biosignature Gases of Terrestrial Exoplanets”, Advisor: Sara Seager*
- 2009     **M.Sc., Astrophysics**, Tsinghua University  
*“Evolution of MHD Voids, Formation of Magnetars, and Observations of Geomagnetospheric Reconnections”, Advisor: Yu-Qing Lou*
- 2009     **French Engineer’s Degree**, École Centrale Paris
- 2007     **B.Sc., Mathematics and Physics**, Tsinghua University

## EMPLOYMENT

- 2015-     **Research Scientist**, Jet Propulsion Laboratory
- 2013-15   **Hubble Postdoctoral Fellow**, Jet Propulsion Laboratory
- 2013     **Assistant Scientist**, California Institute of Technology

## SELECTED AWARDS AND HONORS

- 2013-16   **NASA Hubble Postdoctoral Fellowship**
- 2011-13   **NASA Earth and Space Science Fellowship**
- 2012     **Barrett Prize**, Massachusetts Institute of Technology
- 2012     **Fellowship**, Sao Paulo Advanced School of Astrobiology
- 2011     **Fellowship**, NASA Astrobiology Institute Summer School
- 2009     **Presidential Fellowship**, Massachusetts Institute of Technology
- 2009     **Best Master Dissertation**, Tsinghua University
- 2009     **Wu You-Xun Prize**, Tsinghua University
- 2007-08   **AMD Space Science Award**, Tsinghua University
- 2006-07   **Dean’s Summer Student Scholarship**, University College London
- 2005-07   **Fellowship**, École Centrale Paris
- 2002     **Silver Medal**, The 19<sup>th</sup> National Physics Olympiad of China

## SERVICE

- 2015 **Panel Reviewer**, Hubble Space Telescope Cycle 23
- 2014 **Principal Investigator** of science return from direct-imaging exoplanet missions, NASA Exoplanet Exploration Program
- 2013- **Referee** for ApJ, ApJS, A&A, Astrobiology, Icarus, EPSL, GRL, and Astrophysics and Space Science
- 2012- **Panel Reviewer** for NASA Planetary Atmospheres Program, NASA Exoplanet Research Program, and NASA Earth and Space Science Fellowship
- 2012-13 **Member**, Working Group 1 (Atmospheric Chemistry, Dynamics and Spectral Retrieval) of the Exoplanet Characterization Observatory (EChO) mission study

## INVITED TALKS

- 2016 Conference: The 227<sup>th</sup> Meeting of the American Astronomical Society, Kissimmee, FL
- 2015 Observatory of Côte d'Azur, Conference: Exoplanetary Atmospheres and Habitability, Nice, France
- 2015 Conference: IAU XXIX General Assembly, Honolulu, Hawaii
- 2015 Conference: Planetary Systems: a Synergistic View Conference, Quy Nhon, Vietnam
- 2015 University of California, Santa Barbara, KITP Conference: Physics of Exoplanets: From Earth-sized to Mini Neptunes
- 2014 California Institute of Technology, Kliegel Lectures in Planetary Sciences
- 2014 University of California, Los Angeles, Planetary Seminar
- 2013 University of California, Los Angeles, iPLEX Lunch Seminar
- 2013 California Institute of Technology, Yuk Lunch Seminar
- 2012 Harvard-Smithsonian Center for Astrophysics, SSP Seminar
- 2012 Institute for Advanced Study, Seminar

## PUBLICATIONS

### Refereed Publications

13 first-author papers, h-index = 10, \*student advised

[18] **Renyu Hu**, David Kass, Bethany L. Ehlmann, and Yuk L. Yung (2015), *Tracing the Fate of Carbon and the Atmospheric Evolution of Mars*, **Nature Communications**, 6, 10003

[17] Avi Shporer and **Renyu Hu** (2015), *Studying Atmosphere-Dominated Kepler Phase Curves*, **AJ**, 150, 4

- [16] **Renyu Hu**, Sara Seager, and Yuk L. Yung (2015), *Helium Atmospheres on Warm Neptune- and Sub-Neptune-Sized Exoplanets and Applications to GJ 436 b*, **ApJ**, 807, 8
- [15] \*Peter Gao, **Renyu Hu**, Tyler Robinson, Cheng Li, and Yuk L. Yung (2015), *Stabilization of CO<sub>2</sub> Atmospheres on Exoplanets around M Dwarf Stars*, **ApJ**, 806, 249
- [14] **Renyu Hu**, Brice-Oliver Demory, Sara Seager, Nikole Lewis, and Adam P. Showman (2015), *A Semi-Analytical Model of Visible-Wavelength Phase Curves of Exoplanets and Applications to Kepler-7 b and Kepler-10 b*, **ApJ**, 802, 51
- [13] **Renyu Hu** and Sara Seager (2014), *Photochemistry in Terrestrial Exoplanet Atmospheres III: Photochemistry and Thermochemistry in Thick Atmospheres on Super Earths*, **ApJ**, 784, 63
- [12] Sara Seager, William Bains, and **Renyu Hu** (2013), *Biosignature Gases in H<sub>2</sub>-Dominated Exoplanet Atmospheres*, **ApJ**, 777, 95
- [11] Sara Seager, William Bains, and **Renyu Hu** (2013), *A Biomass Model for Exoplanet Biosignature Gases*, **ApJ**, 775, 104
- [10] **Renyu Hu**, Sara Seager, and William Bains (2013), *Photochemistry in Terrestrial Exoplanet Atmospheres II: H<sub>2</sub>S and SO<sub>2</sub> Photochemistry in Anoxic Atmospheres*, **ApJ**, 769, 6
- [9] **Renyu Hu**, Sara Seager, and William Bains (2012), *Photochemistry in Terrestrial Exoplanet Atmospheres I: Photochemistry Model and Benchmark Cases*, **ApJ**, 761, 166
- [8] **Renyu Hu** and Shuang-Nan Zhang (2012), *Quasars' Optical Polarization and Balmer Edge Feature Revealed by Ultra-violet, and Polarized Visible to Near Infrared Emissions*, **MNRAS**, 426, 2847-2858
- [7] **Renyu Hu**, Kerri Cahoy, and Maria T. Zuber (2012), *Mars CO<sub>2</sub> Condensation Above The North and South Poles Revealed by Radio Occultation, Climate Sounding, and Laser Ranging*, **J. Geophys. Res.**, 117, E07002
- [6] **Renyu Hu**, Bethany L. Ehlmann, and Sara Seager (2012), *Theoretical Spectra of Terrestrial Exoplanet Surfaces*, **ApJ**, 752, 7-21
- [5] **Renyu Hu** (2010), *Transport of the First Rocks of the Solar System by X-winds*, **ApJ**, 725, 1421-1428
- [4] Yu-Qing Lou and **Renyu Hu** (2010), *General Polytopic Magnetofluid under Self-Gravity: Voids and Shocks*, **New Astronomy**, 15, 198-214
- [3] **Renyu Hu** and Yu-Qing Lou (2009), *Magnetic Massive Stars as Magnetar Progenitors*, **MNRAS**, 396, 878-886
- [2] **Renyu Hu** and Yu-Qing Lou (2008), *Self-Similar Champagne Flow of Polytopic HII Regions*, **MNRAS**, 390, 1619-1634

[1] **Renyu Hu**, Yulia V. Bogdanova, Christopher J. Owen, Claire Foullon, Andrew N. Fazakerley, and Henri Rème (2008), *Cluster Observations of the Mid-Altitude Cusp under Strong Northward Interplanetary Magnetic Field*, **J. Geophys. Res.**, 113, A07S05

### **Submitted Publications**

[1] **Renyu Hu**, Anthony Bloom, Peter Gao, Charles E. Miller, and Yuk L. Yung (2016), *Hypotheses for near-surface exchange of methane on Mars*, **Astrobiology**, submitted

### **Publications in Preparation**

[1] **Renyu Hu** (2016), *Measurement of Methane Mixing Ratio and Cloud Pressure from Exoplanet Reflection Spectrum*, to be submitted

### **Reports, White Papers, Book Chapters, and Conference Proceedings**

[5] Kevin France, ... **Renyu Hu**, and 33 coauthors (2015), *Characterizing the Habitable Zones of Exoplanetary Systems with a Large Ultraviolet/Visible/Near-IR Space Observatory*, in response to NASA call for white papers: Large Astrophysics Missions to Be Studied by NASA Prior to the 2020 Decadal Survey (arXiv: 1505.01840)

[4] **Renyu Hu** (2014), *Ammonia, Water Clouds and Methane Abundances of Giant Exoplanets and Opportunities for Super-Earth Exoplanets*, Report of a quick study of science return from direct-imaging exoplanet missions, commissioned by the NASA Exoplanet Exploration Program on behalf of the WFIRST/AFTA Science Definition Team and the Exo-S and Exo-C Science and Technology Definition Teams (arXiv:1412.7582)

[3] **Renyu Hu** (2014), *Photochemistry in Terrestrial Exoplanet Atmospheres*, Invited Chapter in *Planetary Exploration and Science: Recent Results and Advances*, ed. S. Jin et al., Springer-Verlag

[2] Roy van Boekel, Björn Benneke, Kevin Heng, **Renyu Hu**, and 30 coauthors (2012), *The Exoplanet Characterization Observatory (EChO): performance model EclipseSim and applications*, in *Proceedings of SPIE 8442, Space Telescopes and Instrumentation 2012: Optical, Infrared, and Millimeter Wave*

[1] **Renyu Hu** and Yu-Qing Lou (2008), *Rebound Shock Breakouts of Exploding Massive Stars: A MHD Void Model*, in *AIP Conference Proceedings*, 1065, 310-313 (arXiv:0808.3905)

### **SELECTED CONFERENCE PRESENTATIONS**

**Renyu Hu** (2015), *Equilibrium and Disequilibrium Chemistry in Evolved Exoplanet Atmospheres*, DPS 47<sup>th</sup> Meeting, National Harbor, MD

**Renyu Hu** (2015), *Colors of Alien Worlds from Direct Imaging Exoplanet Missions*, IAU XXIX General Assembly, Honolulu, Hawaii

**Renyu Hu** (2015), *Characterizing Exoplanet Atmospheres with Visible-Wavelength Phase Curves*, IAU XXIX General Assembly, Honolulu, Hawaii

**Renyu Hu** (2015), *Measuring Atmospheric Compositions of Giant Exoplanets and Distinguishing Water-World Exoplanets with Direct-Imaging Exoplanet Missions*, Hubble Fellows Symposium, Baltimore, MD

**Renyu Hu**, Peter Gao, Charles E. Miller, and Yuk L. Yung (2015), *Hypotheses for a Near-Surface Reservoir of Methane and Its Release on Mars*, 46<sup>th</sup> LPSC, Woodlands, TX, LPI Contribution No. 1832, p.2279

**Renyu Hu** (2015), *Highly Evolved Exoplanet Atmospheres*, AAS 225<sup>th</sup> Meeting, Seattle, WA

**Renyu Hu**, David M. Kass, Bethany L. Ehlmann, and Yuk L. Yung (2014), *Carbon Reservoir History of Mars Constrained by Atmospheric Isotope Signatures*, AGU Fall Meeting, San Francisco, CA

Peter Gao, **Renyu Hu**, Tyler D. Robinson, and Yuk L. Yung (2014), *The Role of Hydrogen in Determining the Stability of CO<sub>2</sub> Atmospheres of Terrestrial Exoplanets Around M Dwarfs*, DPS 46<sup>th</sup> Meeting, Tucson, AZ

**Renyu Hu** (2014), *Helium Atmosphere on Neptune-Sized Exoplanet GJ 436 b Formed by Irradiation Driven Escape*, 40<sup>th</sup> COSPAR Scientific Assembly, Moscow, Russia

**Renyu Hu** and Sara Seager (2014), *H<sub>2</sub>S and SO<sub>2</sub> Photochemistry in Anoxic Atmospheres of Terrestrial Exoplanets*, 45<sup>th</sup> LPSC, The Woodlands, TX, LPI Contribution No. 1777, p.1481

**Renyu Hu** (2014), *Helium Atmosphere on Neptune-Sized Exoplanet GJ 436 b Formed by Irradiation Driven Escape*, Hubble Fellows Symposium, Baltimore, MD

**Renyu Hu** (2014), *Helium-Dominated Atmosphere on Neptune-Size Planet GJ 436 b*, Exoclimates III Conference, Davos, Switzerland

**Renyu Hu** and Sara Seager (2013), *Thermochemistry and Photochemistry in Thick Atmospheres on Super Earths and Mini Neptunes*, AGU Fall Meeting, San Francisco, CA

**Renyu Hu** and Sara Seager (2013), *Photochemistry in Thick Atmospheres on Super Earths*, 44<sup>th</sup> LPSC, The Woodlands, TX, LPI Contribution No. 1719, p.1428

**Renyu Hu** and Sara Seager (2013), *Atmospheric Photochemistry and Potential Biosignatures on Terrestrial Exoplanets*, AAS 221<sup>st</sup> Meeting, Long Beach, CA

**Renyu Hu** (2012), *Photochemistry of Terrestrial Exoplanet Atmospheres and Applications in Searching for Biosignature Gases*, IAU Symposium 293, Beijing, China

**Renyu Hu** (2012), *A New Photochemistry Code for Terrestrial Exoplanet Atmospheres*, Modeling Atmospheric Escape Workshop, Charlottesville, VA

**Renyu Hu**, Kerri Cahoy, and Maria T. Zuber (2011), *Particle Size of CO<sub>2</sub> Condensates in Mars' Atmosphere: a Joint Analysis of Radio Occultation, Climate Sounder and Laser Ranging Experiments*, AGU Fall Meeting, San Francisco, CA

**Renyu Hu** (2011), *Radial Transport of First Solids of the Solar System by X-Winds*, Workshop on Formation of the First Solids in the Solar System, Kauai, HI, LPI Contribution No. 1639, p.9061

**Renyu Hu**, Sara Seager, and William Bains (2011), *Can Hydrogen Sulfide Gas Be a Biosignature in a Habitable Exoplanet?*, AAS 218<sup>th</sup> Meeting, Boston, MA

**Renyu Hu** (2010), *Transport of First Rocks of The Solar System by X-winds*, ESF Research Conference: Putting our Solar System in Context, Obergurgl, Austria

**Renyu Hu** and Yu-Qing Lou (2010), *Fossil Fields as The Origin of Ultra-Intense Magnetic Fields on Magnetars*, AAS 215<sup>th</sup> Meeting, Washington, DC

**Renyu Hu** and Yu-Qing Lou (2009), *Magnetic massive stars as magnetar progenitors*, The First Panda Symposium, Lijiang, China,

**Renyu Hu** and Yu-Qing Lou (2008), *Rebound Shock Breakouts of Exploding Massive Stars: A MHD Void Model*, Nanjing Gamma-Ray Burst Conference, Nanjing, China

**Renyu Hu**, Yulia V. Bogdanova, Christopher J. Owen, Claire Foullon, Andrew N. Fazakerley, and Henri Rème (2008), *Cluster Observations of the Mid-Altitude Cusp under Strong Northward Interplanetary Magnetic Field*, 37<sup>th</sup> COSPAR Scientific Assembly, Montreal, Canada

## **EXTERNALLY SPONSORED RESEARCH PROJECTS**

*Optimizing WFIRST Coronagraph Science*

Principal Investigator: Bruce Alan Macintosh

Co-Is: **Renyu Hu**, and 14 co-Is

Sponsor: NASA

Program: WFIRST Science Investigation Teams and Adjutant Scientists

Funding Period: December 1, 2015 to November 30, 2020

Total funding: TBD

*Harnessing the Power of the WFIRST-Coronagraph: A Coordinated Plan for Exoplanet and Disk Science*

Principal Investigator: Margaret Turnbull

Co-Is: **Renyu Hu**, and 10 co-Is

Sponsor: NASA

Program: WFIRST Science Investigation Teams and Adjutant Scientists  
Funding Period: December 1, 2015 to November 30, 2020  
Total funding: TBD

*Detecting and Characterizing Exoplanets with the WFIRST Coronagraph: Colors of Planets in Standard and Designer Bandpasses*

Principal Investigator: Margaret Turnbull  
Co-Is: **Renyu Hu**, Tristan L'Ecuyer  
Sponsor: NASA  
Program: WFIRST Preparatory Science  
Funding Period: April 1, 2015 to March 31, 2018  
Total funding: \$539,346

*Chemical Fingerprints of Alien Worlds – Towards an Evolutionary View of Mars and Terrestrial Exoplanet Atmospheres*

Principal Investigator: Wesley A. Traub  
Science-PI: **Renyu Hu**  
Sponsor: NASA  
Program: NASA Hubble Postdoctoral Fellowship  
Funding Period: December 16, 2013 to December 15, 2016  
Total funding: \$316,500

*Photochemistry of Super Earth Exoplanet Atmospheres*

Principal Investigator: Sara Seager  
Science PI: **Renyu Hu**  
Sponsor: NASA  
Program: NASA Earth and Space Science Fellowship  
Funding Period: September 1, 2011 to August 30, 2013  
Total funding: \$60,000

**Pending**

*Characterization of Local Environment and Habitability as Controlled by Interaction of the Martian Atmosphere with the Surface and the Regolith*

Principal Investigator: Yuk L. Yung  
Co-Is: **Renyu Hu**, John Eiler, Sally Newman  
Sponsor: NASA  
Program: Mars Science Laboratory Participating Scientist  
Funding Period: October 5, 2015 to September 29, 2019  
Total funding: \$615,545

*Constraining Early Mars's Atmosphere and Habitability with Isotopic Measurements*

Principal Investigator: **Renyu Hu**

Co-Is: Bethany Ehlmann, Yuk Yung

Sponsor: NASA

Program: Habitable World

Funding Period: August 1, 2016 to July 31, 2019

Total funding: TBD

## **MEDIA REPORTS**

- 2015 *Mystery on Mars: Does Methane Really Indicate Life?* by Space.com
- 2015 *Mars' Ancient Atmosphere Wasn't Very Thick After All*, by Discovery, Yahoo News, and ScienceDaily
- 2015 *Helium-Filled Exoplanets Likely Float Throughout the Galaxy*, by Discovery, Space.com, and Sciencenews.org
- 2013 *Investigating Exoplanet Surfaces*, by Astrobiology Magazine, Phys.org, and SciTech Daily
- 2012 *Mars Snowflakes Are as Tiny as Red Blood Cells*, by CBS, Nature, Discovery, National Geographic, Reuters, Daily Mail, and Space.com
- 2011 *How Astronomers May Hunt for Life on Alien Planets*, by Astrobiology Magazine, New Scientist, Space.com, and The Daily Galaxy

## **TEACHING EXPERIENCE**

- 2015 **Co-Instructor**, California Institute of Technology, Class Ge 194: Isotopic Tracers of Mars Atmosphere-Surface Interactions
- 2015 **Guest Lecturer**, California Institute of Technology, Class Ge 159: Planetary Evolution and Habitability
- 2014 **Professional Development Program**, Institute for Scientist and Engineer Educators, University of California, Santa Cruz
- 2012 **Teaching Certificate Program**, Massachusetts Institute of Technology
- 2018-10 **Teaching Assistant**, Tsinghua University, Class: Quantum Mechanics

## REFERENCES

### **Yuk L. Yung**

Smits Family Professor of Planetary Science  
California Institute of Technology  
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### **Sara Seager**

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### **Wesley A. Traub**

Senior Research Scientist  
JPL Project Scientist of WFIRST-AFTA Mission  
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### **Robert E. Johnson**

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